High Vacuum, High Airflow Blower Testing and Design for Soil Vapor Intrusion Mitigation in Commercial Buildings

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1920’s Brick and Wood Building

**Front**
- Soil gas: 182,000 ug/m³ *
- Indoor Air: 245 ug/m³ *

**Back**
- Soil gas: 182,000 ug/m³ * (NJ Screening Level 27 ug/m³)
- Indoor Air: 245 ug/m³ * (NJ Screening Level 3 ug/m³)

* Actual concentrations confidential
Soil Depressurization Complicated by:

- High Ground Water
- 18 inches of Compacted Clay and Broken Concrete Between Finish Floor and Lower Slab
- Unsealed Areas Behind Finished Walls
- Floor Drain Network and Backfilled Waste Pit
Stack Effect Contributors

- No Insulation Above Drop Ceiling
- Wind Driven Ventilator
- Broken Windows
Slab Openings

35 to 1

1174 to 1

540 to 1

Attenuation between sub-slab & interior varied because of slab leakage and building ventilation
Diagnostic Investigation

2.5 inch Diagnostic Suction Point

Measuring Airflow and Sub Slab Static Vacuum
Determining Vacuum Field Extension

Airflow measured before & after Shop Vacuum

Vacuum Field Extension measured with Micro Manometer
Bench Test of 6.5 HP Shop Vacuum versus Common Fans

Test date 08/31/10

Max. Vacuum 47.5"

Max. 159 CFM

Static Vacuum (in H2O)

Flow Rate SCFM

Shop Vacuum may Over Predict System Performance
-0.008” PFE radius from each suction hole

Total Airflow
528 CFM
Choosing Blowers

Group Convention Blowers  OR  Experiment with Radial Blowers

Building required 600+ CFM
Blowers were Benched Tested to Develop Performance Curves

- Resistance is applied as:
  - Static Vacuum
  - Airflow
  - Electrical Power Consumption is measured.

Results are available at www.WPB-Radon.com
Flow Tech Fan 40/75 with 1.5 HP Single Phase Motor

Test date: 12/1/09

Bench Test of FTF 40/75

Note: Service Factor Limitation
S7 Soil resistance versus Fan Airflow

- Maximum airflow FT 40/75
  - 350 cfm
- Force
  - 120 ÷ 4 = 30 cfm
- 7 suctions
- 4 suctions
- FT 40/75
  - 350 ÷ 7 = 57 cfm
- HS2000
  - 68 ÷ 2 = 34 cfm
- HS5000
- 2 suctions
- 131 cfm during PFE test

Pressure drop in inches of water versus airflow

S7 Therapy Rm = High Flow Suction Hole
S1 Soil resistance versus Fan Airflow

01/13/2010

CFM

100
80
60
40
20
10

HS 2000

HS 5000

2 suctions

1 suction

Force

FT 40/75 88 ÷ 2 = 44 cfm

FT 4075

HS2000 50 ÷ 2 = 25 cfm

HS fans 35 ÷ 1 = 35 cfm

Force 19 ÷ 1 = 19 cfm

71 cfm during PFE test

Pressure drop in inches of water versus airflow

S1 = Medium Flow Suction Hole
S12 Visiting Rm = Low Flow Suction Hole
Radial Blower

Radial Blower Wheel

Amperage measured at start up
17 Suction Holes.

2 FTF40/75

1 HS2000
Building Interior

Therapy Room:  
Pipe left exposed  
Perimeter was sealed

Patient Exam Room  
Pipe encased
Discovered Major Slab leakage

Excessively High Airflow Measured at Two Risers

Two Inch Gap Around Columns Required Sealing
Maximizing Vacuum by Adjusting Airflow

Measuring Riser Pipe Airflow with a Pitot Tube

Slide Valves Regulate Riser Pipe Airflow
Least Sub-slub Vacuum
-0.005”
- 0.008”
# Fan & Energy Consumption Comparison

## Radial Blowers

<table>
<thead>
<tr>
<th>Fan</th>
<th>CFM</th>
<th>amps</th>
<th>Amps</th>
<th>amp</th>
<th>volts</th>
<th>watts</th>
<th>$/KwHr</th>
<th>Cost/Yr</th>
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<tbody>
<tr>
<td>Sys 2 HS2000</td>
<td>40</td>
<td>1.82</td>
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<td></td>
<td>115</td>
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<td>$330</td>
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<td>1466.25</td>
<td>0.18</td>
<td>$2,312</td>
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<tr>
<td><strong>Total CFM</strong></td>
<td><strong>552</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$5800</strong></td>
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</tbody>
</table>

## Conventional Blowers

<table>
<thead>
<tr>
<th>Fan</th>
<th>CFM</th>
<th>amp</th>
<th>Volts</th>
<th>watts</th>
<th>$/KwHr</th>
<th>Cost/Yr</th>
<th># Fans</th>
<th>Cost/Yr</th>
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<tbody>
<tr>
<td>HS5000</td>
<td>30</td>
<td>3.8</td>
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<td>HS2000</td>
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<td>$326</td>
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<td>$979</td>
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<tr>
<td>Force</td>
<td>100</td>
<td>2</td>
<td>115</td>
<td>230</td>
<td>0.18</td>
<td>$363</td>
<td>3</td>
<td>$1,087</td>
</tr>
<tr>
<td><strong>Total CFM</strong></td>
<td><strong>540</strong></td>
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<td></td>
<td></td>
<td></td>
<td><strong>$9600</strong></td>
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### Total CFM 552

**Fan cost $5800**

**Yearly Elec $4,339**

**Cost per month = $362**

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<th>Cost per month =</th>
<th>$402</th>
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**Total CFM 540**

**Fan cost $9600**

**Yearly Elec $4,823**

**Cost per month = $402**
Conclusions

- Building Evaluation and Vacuum Field Extension Testing is Critical to Optimizing a Vapor Mitigation System
- Using Fewer Blowers Reduces Energy and Installation cost
- Soil Resistance vs Blower Performance graphs help determine Optimum Blower & Maximum # of Suctions
- System Optimized by Retesting Soil Resistance after Pit Excavation
- Sealing is Critical to System Performance
- Must NOT exceed Motor Service Factor
- Radial Blowers are an Effective Alternative to Multiple Regenerative Blowers for Low Permeability Soils